An evolving simulation and gaming process to facilitate adaptive watershed management in mountain northern Thailand

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Decentralization of natural resources management provides an opportunity for communities to increase their participation in related decision-making. Research should propose adapted methodologies enabling the numerous local stakeholders of these complex socio-ecological settings to define themselves their problems and to identify agreed-upon solutions. In the research presented in this paper, a Companion Modelling (ComMod) approach combining Role-Playing Games (RPG) and Multi-Agent Systems (MAS) has been conducted in a highland community of Northern Thailand to support collective learning for adaptive land management. A representation of the situation was collectively built and used with local stakeholders as a platform to explore future scenarios. The results of this experiment highlight the need for adaptive and continuously evolving models because learning is evolving by its nature. The initial objective of this ComMod experiment was to address the problem of soil erosion. The participants identified the expansion of perennial crops as a promising solution and these discussions raised in turn a new problem related to unequal ability of villagers to invest in such crops. The researchers flexibly adapted their tools to the new emerging question. After an evaluation of the learning effects of this experiment, this article identifies two main factors that contributed to the success of this learning process : an increased participation of the local stakeholders, and the flexibility of the modelling process. The main suggestion of improvement is a stronger linkage with organizations at a higher institutional level to ensure concrete and sustainable impacts for the communities.

KEYWORDS: Companion modelling, Collective Learning, Multi-Agent System, Role Playing Game, Natural Resource Management, Decentralization, Northern Thailand.

[1]In Thailand, as in other countries in Southeast-Asia, after many decades of highly centralized governance, the general policymaking framework for Natural Resources Management (NRM) favours decentralization and public participation. The 1997 Constitution was an important turning point. Article 79 provides measures to "promote and

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encourage public participation in the preservation, maintenance and balanced exploitation of natural resources and biophysical diversity, and in the promotion, maintenance and protection of the quality of the environment" (Rutherford, 2002). Previous environmental policies had drastically restricted the access to natural resources for the ethnic minorities populating the highlands of Northern Thailand, because their agricultural practices were considered harmful to the environment (Ganjanapan, 2002). Therefore the principle of participation embraced by the so-called “people Constitution” and the establishment of elected *Tambon* councils at the sub-district level provide opportunities for communities to regain control over NRM and to increase their say in public affairs.

But there is a need to develop innovative and context-adapted methodologies and tools to enable the diverse local stakeholders to genuinely participate in decision-making related to local NRM. The current debate in Thailand about the policy of decentralized rural credit implemented since 2002 is particularly illustrative of this need : whereas some academics denounce its negative impact on communities, because of a lack of preparation of villagers to manage such funds, the government is moving ahead to implement this credit policy without more caution.

As in many parts of mountain mainland Southeast Asia, the highlands of Northern Thailand are characterized by increasingly complex and dynamic agrarian situations, including frequent conflicts over the use of land, forest and water resources among an increasing number of stakeholders with different and sometimes contradictory perspectives (Rerkasem and Rerkasem, 1994; Trébuil *et al.*, 1997). Recent publications demonstrate that sustainable NRM in such conditions requires coordination among concerned stakeholders; this coordination is all the more likely to lead to sustainability if it is based on trust (Rudd, 2000; Pretty, 2003) and recognition of interdependence (Leeuwis and Van Den Ban, 2004), and if it is reinforced by functional local institutions (Ostrom *et al.*, 1994). Moreover, farmers in the highlands have to face increasingly uncertain and dynamic situations due to factors such as rapid agroecological changes, destabilizing price fluctuations on markets for cash crops, cross-border immigration, and frequently arbitrary enforcement of environmental policies. Such dynamic socio-ecological systems challenge adaptability of local farming communities and require adaptive management (Holling, 2001). We assume that this can be achieved through the facilitation of a continuous collective learning process (Röling and Wagemakers, 1998). In this study, learning is broadly defined as a change in the way people perceive their social and ecological environment (and consequently the way they act on it), according to their experiences, beliefs, values, intentions, and interactions with other people. As stakeholders have multiple and sometimes conflicting interests, such a collective learning process also includes a negotiation dimension (Leeuwis, 2004). According to Van Paassen (2004), collective learning about NRM issues presents two interrelated dimensions: a better insight in the various stakeholders' perspectives on the problem (to negotiate a joint desired situation), and a better understanding of the system (to explore possible scenarios of changes to achieve this desired situation).

Companion modelling (ComMod) approach is an interdisciplinary approach combining the iterative use of multi-agent systems (MAS) simulations and role-playing games (RPG) to facilitate such a learning process through the collective building of a representation of the situation (Bousquet *et al.*, 1999; ComMod, 2005). Because complex situations are highly uncertain, the objective is not to build a model to predict the future state of the system, but to triggers discussions to explore possible scenarios of solution. As situations are rapidly

evolving, such a model should be adaptive and continuously evolving to accompany not only the evolutions of the situations, but also the changes in participants' preoccupations. Along the learning process, discussions and agreement on possible solutions might raise new problems to be solve and require adapted model to the new emerging questions. This is what happened in the case study presented in this article.

In the Akha village of Mae Salaep, northern Thailand, two successive ComMod cycles were implemented and accompanied changes in focus of discussions along the learning process. In this highland community, in a context of rapid market integration and associated switch from traditional subsistence agriculture to cash cropping, farmers are accused by lowlanders of increased land degradation through soil erosion. As environment policies are being reinforced, the survival of their communities could be threatened by a highly restricted access to farm land. The initial objective of this ComMod experiment was to facilitate a collective learning process in this highland community on the problem of soil erosion (Trébuil *et al*. 2002). At the end of this first cycle, participants identified the expansion of perennial crops as a promising solution and requested to focus the second cycle on the socio-economic aspects related to their adoption.

After presentations of our methods and study site, we briefly describe the first modelling cycle initiated in 1999-2002. This is followed by a detailed presentation of the subsequent cycle conducted in 2004 according to local stakeholders' suggestions of changes. The results and the discussion show how the flexible use of simulation and gaming tools stimulated an evolving collective learning process. The article ends with an evaluation of the selected ComMod approach, lessons from this experiment, and suggestions for improvement.

Methodology

Multi-Agent Systems (MAS) are particularly appropriate to represent and simulate complex NRM problems because they focus on interactions among heterogeneous social agents and their common environment (Bousquet *et al.*, 1993; Lansing and Kramer, 1994). In this study, MAS was implemented using the CORMAS[2] platform designed to understand and simulate complex resource management systems and that is particularly open and flexible. We assume that its flexibility is a prerequisite for its use in an adaptive learning process.

To better involve local stakeholders in the modelling process and the validation of its outputs, we translated the MAS model initially built by the researchers into a Role-Playing Game (RPG). The game helps the local stakeholders to understand the structure and operation of the computerized model and its limits, and gives them a chance to validate, criticize or improve it. This translation is possible because MAS and Role-Playing Games (RPG) have similar components: agents corresponding to roles, the spatial interface to the gaming board, the time step in a simulation to a game round, etc. (Barreteau *et al.*, 2001). According to Duke (1974), gaming is a mode of communication more capable than others to convey complexity. It allows multiple stakeholders to interactively apprehend the complex systems from which they are part. It triggers discussions among them because they share a common representation derived from the game. It is possible to test alternate scenarios in a game, but this quickly becomes very time consuming. In ComMod approach, the association

[2] http://cormas.cirad.fr

of the role playing game with multiple fast runs of MAS simulations can remove this constraint (Barreteau et al. 2001).

Various kinds of associations between MAS and RPG have been tested (D'Aquino *et al.*, 2002). The main methodological phases implemented in this case study are presented in figure 1. At the end of the first ComMod cycle, which is described in details elsewhere (Trébuil *et al.*, 2002), local stakeholders requested several changes in the MAS and RPG models to focus on a new problem. The second cycle was implemented as follows:

(i) Field survey to gather existing knowledge and local stakeholders' perspectives on the new problem to be examined,

(ii) Translation of observed dynamics into MAS and RPG models,

(iii) Preparation of a three days workshop in the village (including gaming & simulation sessions). Two officers of the local agency of Department of Public Welfare (DPW) facilitated our activities. The animation of the game and group debates was conducted by a Thai researcher from our research team, and translation from Thai to Akha was undertaken by one of the two DPW officers originating from this village. This person was also in charge of convoking the villagers. As we requested their presence for three days and they might need to hire day laborers to replace them in the fields, players were given an amount of money equivalent to three daily wages. The 12 players were chosen by the designer of the game in order to represent well the diversity of situations and interests within the community. To ensure continuity in the process, a majority had already played the first game. Thanks to previous field interviews, the players and the relations among them were well known from the research team, what facilitated careful observation, listening and management of the collective discussions.

(iv) First day : gaming sessions. Following a short presentation of the rules of the RPG by the animators, two gaming sessions were implemented. The first one was played according to the researchers' representation of the actual system and was followed by a short collective debriefing. Then players were asked to suggest changes to make the RPG more in touch with their representation of reality, or to test a given scenario to solve the problem at stake. The second gaming session was played according to the suggested new features and rules.

(iv) Second day : individual interviews of the players to better understand their behaviour during the game (for example in relation with their reality), to assess the model, and to evaluate the short-term learning effects of the game.

(v) Modification of the MAS model to integrate the new knowledge acquired during the game, and the participants' suggestions for improvement,

(vi) Third day : plenary session of participatory simulations using the improved MAS model to support discussions and exploration of scenarios,

(vii) Back to the laboratory : more advanced simulations,

(viii) More interviews with several players to assess the impact of this ComMod cycle on their perceptions and behaviours, and to evaluate their interest in the process and their possible wishes for a third cycle.

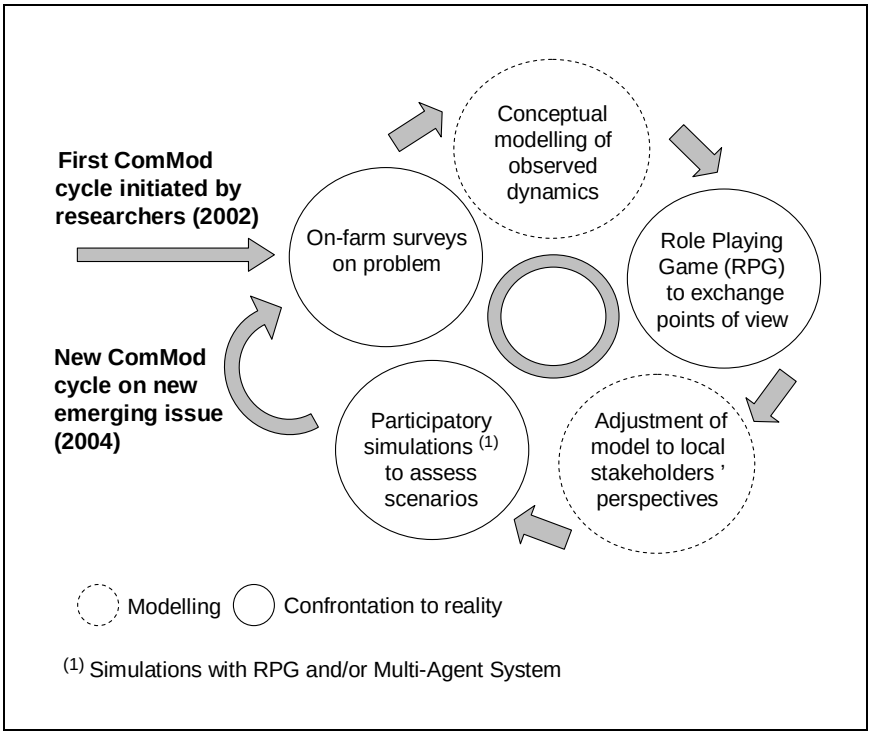


FIGURE 1: The iterative companion modelling process alternating field and laboratory activities during two cycles carried out in Mae Salaep, Chiang Rai Province, upper northern Thailand.

Site description: land degradation in an Akha village of Chiang Rai Province

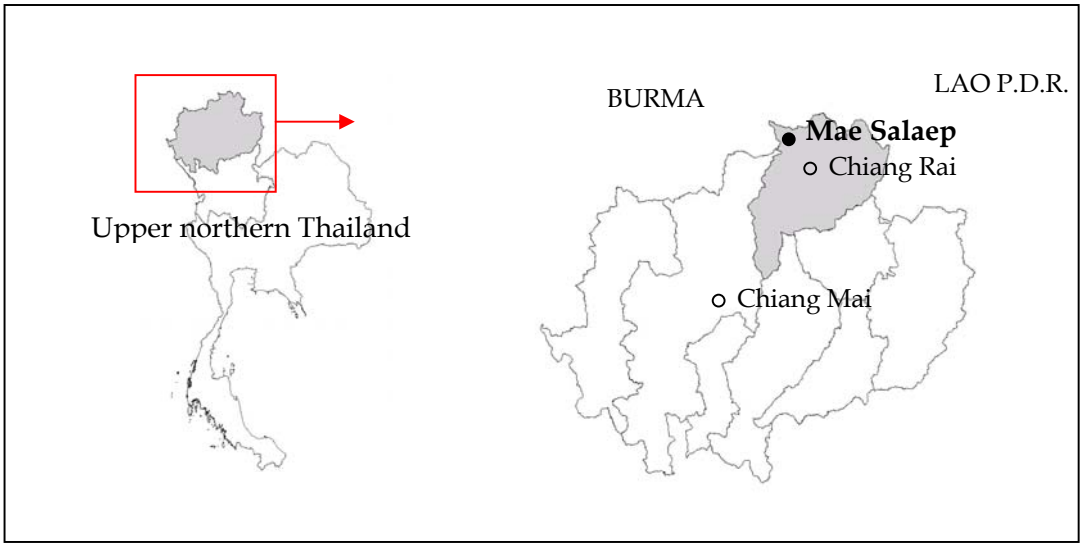


FIGURE 2: Location of Mae Salaep village, Mae Fah Luang District, Chiang Rai Province, upper northern Thailand.

The study site is the main watershed (size: 369 ha, altitude: 500-850 m) of Mae Salaep village, a settlement made of two hamlets inhabited by Akhas people, the dominant ethnic minority in Chiang Rai province. The border with Burma is just a one-day walk across the mountains and the village was established in 1907 by a first group of migrants who crossed the border. In the last two decades, Mae Salaep small-scale farmers have been integrated into the market economy and their former agrarian system based on swiddening is being replaced by semi-permanent and cash crop-based agriculture (Trébuil *et al.*, 2000). The perceived increase of the risk of soil erosion on steep slopes is becoming a major issue because lowlanders (Thai citizens living in the plains and the cities) complain about flash floods and sedimentation in their irrigation reservoirs. The Royal Forestry Department (RFD) threatens highlanders to further restrict their access to farm land. But whether the risk of soil erosion is increasing or not, and how to prevent this problem is a complex issue. Land degradation is not only related to agro-ecological factors, but also socio-economic ones determining the choice and extent of cropping systems. Moreover, the households' integration into the market economy led to an extensive socioeconomic differentiation among farmers having different amounts of productive resources, socio-economic objectives and perception of the problem of soil erosion (Trébuil *et al*., 1997).

The initial objective of this ComMod experiment was to facilitate a collective learning process at this highland community focusing on the interactions between diversification into cash cropping and soil erosion, to identify –if needed- acceptable corrective measures with the stakeholders.

Results: the ComMod process in action

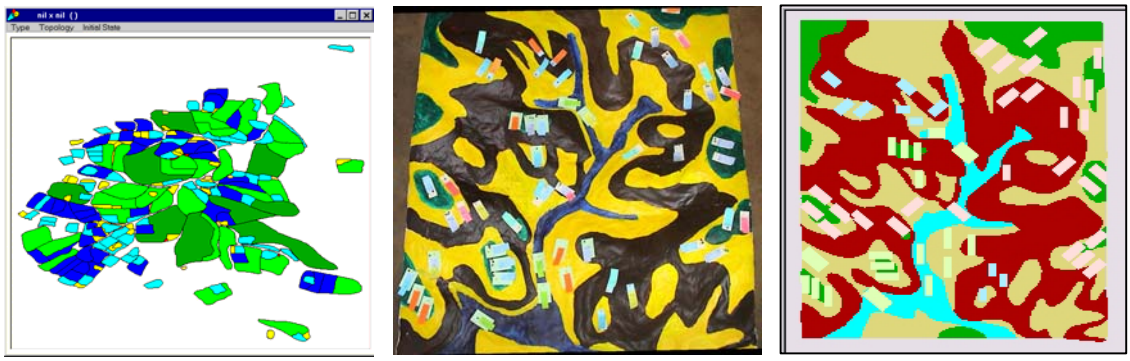
This section presents the results of the two ComMod cycles implemented in Mae Salaep (figure 1). After a brief presentation of the RPG and the two MAS models built in the first cycle, its outcomes and the way participants requested changes for the second cycle are underlined. The results of the second cycle are then presented more in detail, step by step: first understanding of the situation through on-farm surveys, new MAS model and RPG built to focus on the new problem, results of the gaming and simulation sessions.

First ComMod cycle initiated by researchers

The first "researchers' MAS model" (MAE SALAEP 1). The first phase of the research process consisted in the integration of (scientific and indigenous) knowledge on farming systems and soil erosion obtained with on-farm surveys into a first MAE SALAEP 1 model (Trébuil *et al.*, 2002). This model linked to a GIS focused on land use and land degradation dynamics. Considering that the validation of such preliminary "researcher model" would be best done by Mae Salaep farmers themselves, the model was translated into a first RPG that could be described as a simplified non computerized version of the model.

A first role-playing game to validate the initial MAS model. In this first RPG, each participant plays the role of a farmer managing a set of fields located on different slopes of a 3D block model representing the watershed. The 12 players-farmers are given various amounts of land and capital according to the actual farming conditions of the three main types of holdings present in the village: A: small and cash crop-oriented; B: medium and conservative; and, C: large and diversified farming households. There were 3 players of type A and C, and six of B, played by farmers who actually belong to these categories. During each gaming round (corresponding to one crop year), the players successively assign a given crop to each of their fields, harvest their products, go to the market to sell them, receive information on land degradation in their fields, draw a "chance card" (either an exceptional off-farm income or household expense), and finally go to the credit desk to ask and/or reimburse credit if needed. Each year, the general climatic and market price conditions are determined by drawing a card at random. The degree of soil erosion that occurred in their fields is made public on a bulletin board. Four crop years could be played during each half day gaming session.

A second RPG-based MAE SALAEP 2.1 model for communication. The knowledge about farmers land-use strategies acquired during Mae Salaep RPG 1 gaming sessions was used to build a second and much simpler MAE SALAEP 2.1 model, much more similar to the RPG in its rules and features. Instead of the complex GIS maps used in the first MAS model, the visualizing interface was a simplified watershed similar to the gaming board (Figure 3). In this new model, as in the game, 12 agent-farmers manage their fields according to their available productive resources and at each time step they carry out the same set of successive actions and decisions.



GIS spatial interface of the MAS model MAE SALAEP 1*

3D block watershed Gaming board of Mae Salaep RPG 1&2**

Spatial interface of the RPG-based MAS models MAE SALAEP 2.1& 2.2**

FIGURE 3: Simplification of the model visual interface from MAE SALAEP 1 (left) to MAE SALAEP 2.1 (right) which is similar to the gaming board (centre). (*polygonal units are plots of various slopes (various colours); **square units are plots of players / agents located on the various slopes (various colours) of the catchment)

Both MAS models were used to run simulations with the local stakeholders. But we observed that it was easier for participants to follow computer simulations with the RPG-based model.

Outcomes of the first ComMod cycle and changes requested by participants. Mae Salaep farmers validated the researchers' representation of the soil erosion problem, i.e. they found it realistic. During this first cycle, they collectively expressed the idea that the expansion of perennial crops was a promising solution alleviating soil erosion while providing more stable incomes. Therefore they requested to focus more on the socio-economic aspects related to their adoption as many small landholders don't have access to perennial crops. As for the researchers, this first ComMod cycle allowed them to better understand local stakeholders' preoccupations. They decided to adjust their tools to follow this shift of focus from agro-ecological to more socio-economic concerns.

A second ComMod cycle on issue requested by Mae Salaep villagers

The objective of this second cycle was to set up a collective learning process on the socio-economic conditions of adoption of perennial crops to examine the problem of unequal access to this promising solution among the different types of farmers.

Understanding of the new issue through on-farm surveys. Two perennial crops dominate in the current local agrarian system : lychee orchards and small green tea plantations. Lychee orchards were introduced at the beginning of the eighties but large plantations could be adopted by the wealthiest farmers only. Compared to lychee, green tea (that was introduced more recently) is accessible to a broader range of farmers because it reaches maturity faster, requires no input and has more stable prices. It is generally less profitable but also much less risky than lychee. Perennial crops are also interesting because they require less labour than annual crops and provide more time for off-farm employment, a major source of income and investment capacity in this area. However even green tea, the so-called "plantation crop of the poor", is not accessible to all villagers.

As perennial crops require a several years-long wait before harvesting the first products, the rules of allocation of formal and informal credit emerged as a key issue determining ability to invest in perennial crops. Informal credit corresponds to loans settled among villagers, either without interests within networks of acquaintances, or with high interest rates (more than 5% per month) with loan sharks. As for formal credit, beside a traditional village fund created ten years ago, a new government fund was made available in 2002. The older village fund provides small amounts of cash to any household with interest rates fluctuating between 2 and 5 % per month. The government fund provides larger sums, without interest, but is only accessible to well-off households because they are the only ones who can guarantee that they will reimburse the loan. This unequal distribution of the government fund is partially compensated by its redistribution through informal loans within networks of acquaintances. However, as those networks are usually small and quite homogeneous, there is a number of small landholders acquainted with households as poor as them who have no access to this source of credit.

A new focus in the MAE SALAEP 2.2 model. The understanding of the situation described above is a first form of conceptualization, a certain view on reality. Translating this

understanding into a conceptual model and then into a MAS model was another step. Such a model is not neutral, but depends upon the question the modeller wants to analyze, i.e. the objective of the model. So we extracted from our first understanding of the situation the key interacting dynamics relevant to the objectives of the model, which were :

(i) To represent the interactions between investment in perennial crops by different types of farmers, allocation of formal and informal credit, and off-farm activities,

(ii) To explore the interactions between individual decision-making processes at the farming household level and the resultant collective dynamics at the community level,

(iii) To support exploration of scenarios with all the stakeholders.

As two models were available, we did not start from scratch to build this new model. We choose to modify the simplified RPG-based model (MAE SALAEP 2.1) instead of the initial one because the stakeholders were more comfortable with it. The general structure of the new model (called MAE SALAEP 2.2 because it is a new version of the 2.1 one) is displayed on Figure 4. This model is composed of several interacting social, spatial and passive entities (for example the farmers, their plots, and the precipitations). Those entities are assigned with attributes (variable or invariable characteristics) and methods (possible actions).

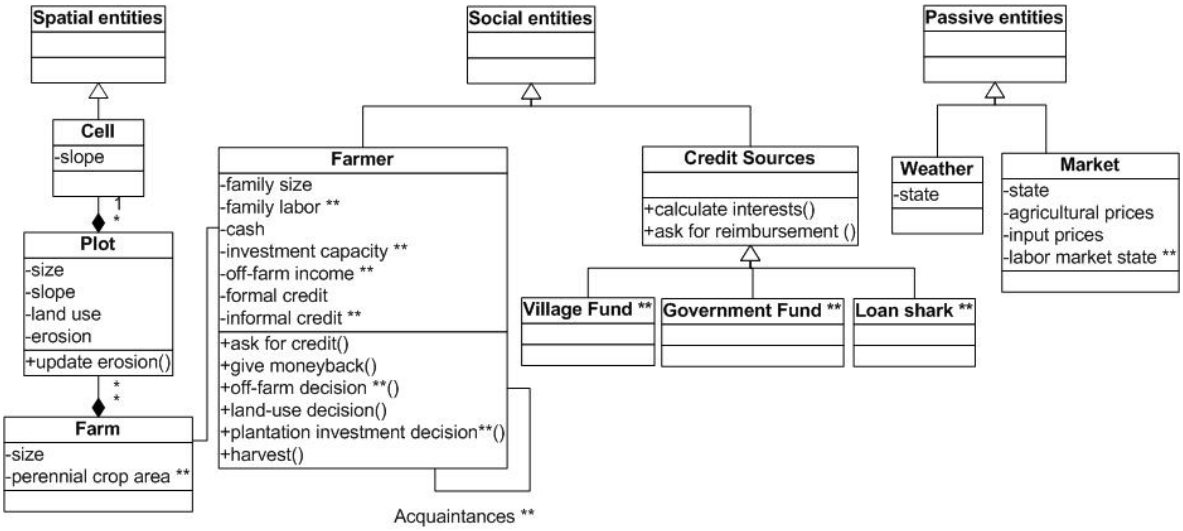


FIGURE 4: Class diagram (i.e. general structure) of the MAE SALAEP 2.2 model underlying the main changes made from the previous MAE SALAEP 2.1 model. (Nota: the double asterisks ** indicate the features added from MASalaep 2.1 to the 2.2 version.)

Two main kinds of changes were made from the previous MAE SALAEP 2.1 model to the 2.2 version : (i) update (for example to take into account the new crops available or the farm differentiation process at work), (ii) changes to accompany the shift of focus from agro-ecological to socio-economic processes. Two formal credit desks (government and village fund), loan sharks, and networks of acquaintances were introduced in the model with their rules for the allocation of credit. Farmers' individual decision-making processes regarding investment in perennial plantations, decision to send (or not) family labour work off-farm and search for credit were also modelled in detail. In the model, if credit is needed, a farmer will successively try to find the required loan with the government fund (no interests), his

acquaintances, the village fund, and at the very end the loan sharks. Informal credit sources are also needed when a farmer cannot reimburse a formal credit fund. When an agent falls into debts with loan sharks, he sends part of his family labour to work in off-farm activities. If this is not enough, as debts keep growing, there is a moment when he is forced to sell his land and leave the village. A labour constraint was also introduced into the model. The farming households have 1, 2 or 3 workers. Each year, they have more or less profitable off-farm opportunities (the wealthiest farmers having the most profitable ones) which they take or not, knowing that this might introduce a labour constraint limiting areas planted with annual crops. Because of the change of focus, new relevant indicators were also selected to follow simulations and analyze their results (presented in a section later on).

To confront this representation of the system to the villagers' one, the new MAS model was translated into a new role-playing game.

A new role-playing game to stimulate exchanges on adoption of plantation crops. The objectives of this new game (called Mae Salaep RPG 2) were as follows:

(i) to stimulate exchanges between researchers and local stakeholders, i.e. to decrease the gap between their respective representations of the problem of unequal access to perennial crops.

(ii) to stimulate exchanges among the local stakeholders themselves, i.e. to facilitate dialogue among the three main types of farmers having different points of view and interest regarding the expansion of perennial crops and the rules for allocating credit within the community.

The changes made in Mae Salaep RPG 1 to conceive this new RPG 2 were almost the same than the modifications made in MAE SALAEP 2.1 model to build its 2.2 version (see previous section). Because a gaming session should not be too long to remain lively, we could not add more features and rules (the socio-economic ones) without simplifying some other aspects. We chose to simplify agro-ecological aspects to accompany the requested shift of focus, as presented in the Table 1.

TABLE 1: Main modifications of Mae Salaep RPG 1 carried out to build the new Mae Salaep RPG 2 game.

Mae Salaep RPG 1	Mae Salaep RPG 2
Updating	
- Perennial crops : possibility to grow lychee only	- Possibility to grow tea and lychee
- Extent of farm size differentiation: from 1 to 4	- Extent of farm size differentiation: from 1 to 8
New socio-economic features and rules	
- One formal credit source	- Two distinct formal credit sources: government and village funds
- No quantification of farm labour	- Allocation of a number of workers per family
- No labour force constraint	- Maximum area of 1.8 ha of annual crops per family worker not involved in off-farm activities
- One chance card drawn by the	- Two chance cards: expenses (compulsory) and

player: either a special expense or an amount of off-farm income	off-farm opportunities (optional)
- Same off-farm opportunities for all players	- Specific off-farm cards for each type of farm
Simplification of agro-ecological features	
- Soil erosion cards distributed and displayed	- No erosion cards
- No distinction between perennial and annual crops	- Perennial crops represented by permanent pins, and annual crops by stickers removed after harvest

During gaming sessions, beside a general observation of players' behaviours, observers focus on particular aspects. Whereas in the first game the focus was on the discussions among players about soil erosion damages in their fields, in the second game the focus was on informal exchanges of cash among them. Thanks to previous interviews, the actual relationships among the players were known in advance and allowed to observe whether or not the exchanges occurred within networks of acquaintances.

Outputs of RPG 2 gaming sessions and debriefing

In this section, we present the outputs of the gaming session of Mae Salaep RPG 2 and the discussions it generated among stakeholders.

A first gaming session highlighting social inequity. During the first gaming session, medium-sized and large landholders (type B and C) invested massively in tea and lychee plantations. They asked credit to the credit institutions, but as it was not sufficient, they opted immediately for informal credit. The small landholders (type A) chose much less risky strategies. They planted mainly low input annual crops, and their low agricultural incomes were not sufficient to pay for home consumption expenses. Because everybody needed cash, the players were eager to draw off-farm opportunities cards, the wealthiest hoping to get the very profitable passport to work in Taiwan. Off-farm incomes were a main source of cash and these revenues were extensively redistributed among players through numerous informal exchanges (mainly within networks of acquaintances).
This gaming session highlighted the problem of social inequity regarding investments in plantation crops because of unequal access to credit.

Collective debriefing : exchange of perspective on the problem and identification of solutions. In the individual interviews, participants insisted on the realism of what happened during this first gaming session. This stimulated discussions among them to solve the problem. During the collective debriefing, they raised important questions such as: how could they change the rules of formal and informal credit so that smallholders (type A) have a better access to credit? Is it possible to change those rules? Would the smallholders benefit from such a change or would they face a too high risk of bankrupt? What would be the consequence for the others (type B and C)? They exchanged their views on these questions and two different solutions were proposed. An old participant suggested to solve the problem with informal credit: "It is not possible to change the rules of formal credit. Informal credit is

more efficient. They should ask me, I would agree to lend them money without interest." On the other side, some younger participants suggested changes in the formal credit, and more precisely the rules of the government fund: they proposed a 3-year grace period for smallholders. The latter said that to be able to reimburse this credit, they should be allowed to send all their family labor work off-farm until the plantations reach maturity.

Second gaming session: test of a suggested solution. After discussion, participants agreed to test the second suggestion (new rules of allocation of formal credit) in the afternoon gaming session. All the smallholders players invested in tea plantations and succeeded in reimbursing their loans. The other participants also had less cash constraints because most of their plantations had reached maturity. Because they considered they had enough money, numerous players refused off-farm opportunities, even if they had "nothing to lose" as they had no labour constraint.

Results of simulations of scenarios with the MAE SALAEP 2.2 model

In the individual interviews of the second day, players validated most of the game's features and made a few suggestions of improvements that were integrated into the MAS model. On the third day, suggested scenarios could be tested with the participants through simulations with the model. Players could easily understand the functioning and the limits of the model because of its similarities with the game.

Three factors varied in the simulated scenarios: (i) the duration of the grace period of the government fund (1 or 3 years), (ii) its distribution amongst the 3 types of farms, and (iii) the characteristics of the networks of acquaintances for informal credit (figure 5). We analyzed the effects of these factors on two main indicators at the end of each simulation (15 years): (i) the area under perennial plantation in each type of farm (ecological indicator), (ii) the proportion of bankrupt farms among each type of farm (socio-economic indicator).

The three scenarios presented in figure 6 were tested in plenary sessions with the participants to support collective debriefing:

(i) The first scenario corresponds to the current situation, i.e. the rules for the operation of formal and informal credit are similar to the actual ones: one-year long loans from the government fund distributing 0, 10, and 20 thousands Bahts[3] to type A, B, and C farms respectively.

(ii) The second scenario tests new rules for the operation of informal credit corresponding to the suggestion of the old player: the lack of access to credit of type A smallholders should be solved through informal credit. This is translated into a scenario with larger and more heterogeneous social networks allocating informal credit (Figure 5). This scenario is very efficient to reduce the number of bankrupt smallholders but does not allow them to increase their investments in plantation crops. This is because they borrow money from their acquaintances only for urgent family consumption needs, not for investment. This scenario is quite theoretical because there is currently no explicit rule in the functioning of informal credit in the village.

[3] In April 2005, 1 Thai baht= 0,0193 euros.

(iii) The third scenario is implemented with a new set of rules for formal credit[4]: three-year long loans of 12, 24, and 54 thousands baths for type A, B, and C farms respectively. This option enables the three types of farmers to invest significantly more in plantation crops. More simulations conducted in the laboratory show smallholders manage to reimburse the loan only if it remains below a certain level. In this case, they face less risk of bankruptcy than in the current situation thanks to the high and stable incomes from their plantations. However, the most efficient way to reduce their risk of bankruptcy in the model remains a change in networks of acquaintances for informal credit (scenario 2).

These scenarios show the trade-off between ecological, economic and social interests and trigger discussions on how to balance these competing interests.

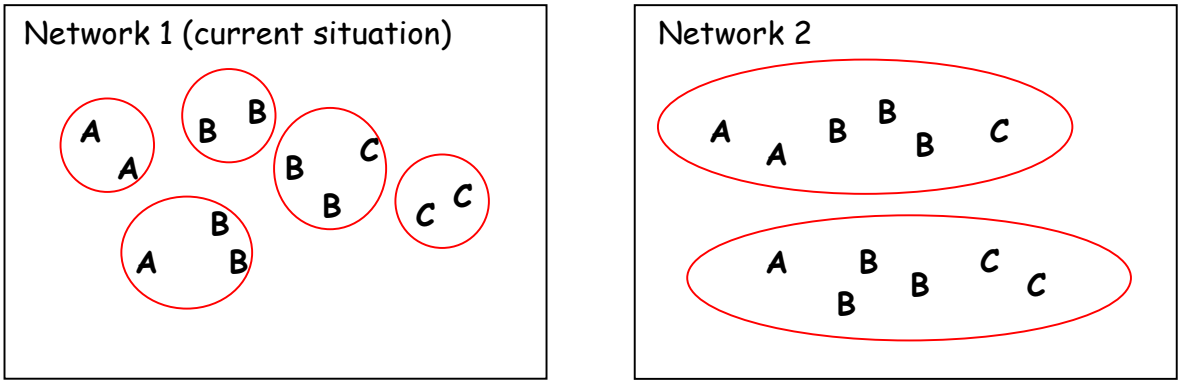


FIGURE 5: Different social networks among three (A, B, C) types of farms to regulate the distribution of informal credit in the simulations. (Nota: A, B and C farmers respectively represent small, medium-sized and large landholders)

[4] The set of rules tested in the game which included a 3-year long grace period only for smallholders was not thoroughly analyzed because afterwards the participants considered this scenario unfair and unacceptable. They considered medium-sized and larger farmers should be awarded similar long-term credit.

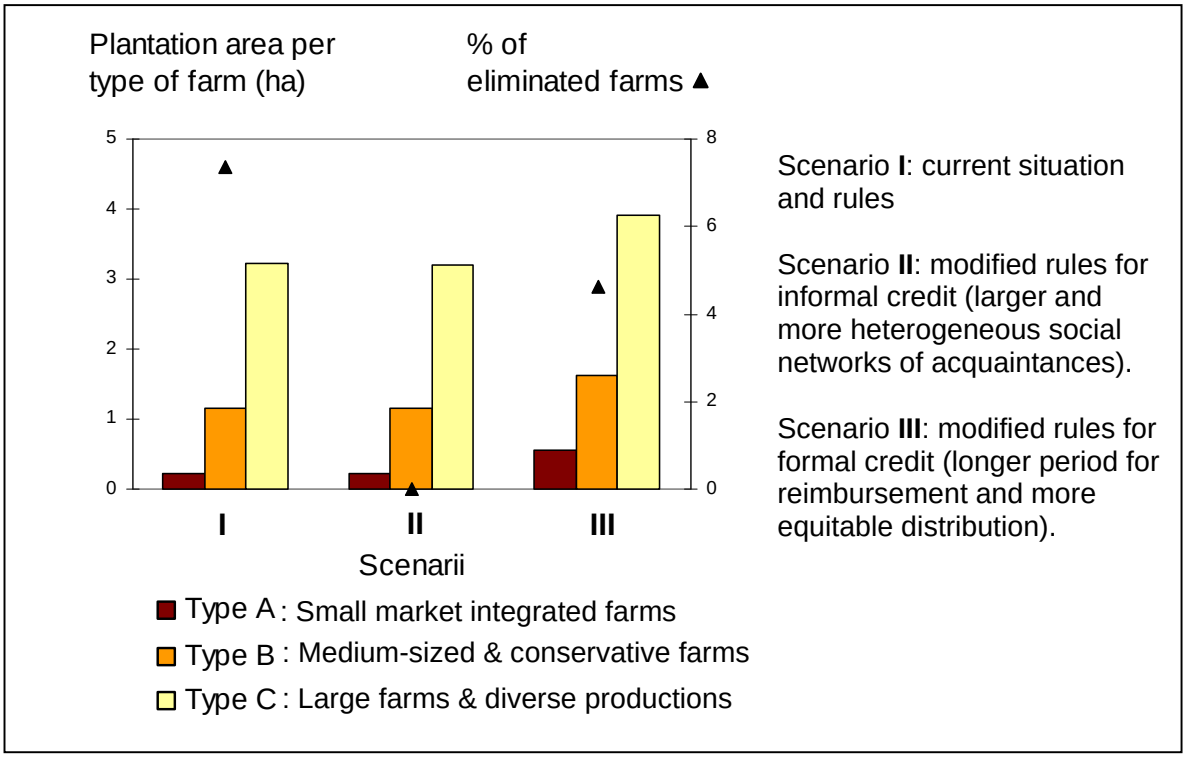


FIGURE 6: Results of simulations exploring the effects of various rules for the allocation of formal and informal credit on the adoption of perennial crops and farmer's differentiation.

Theme of a possible third ComMod cycle

During the final debriefing, the participants said the idea of a 3-year long grace period corresponded to an official request made to the government by hundreds of rural communities across the country. "If tomorrow the government agrees to lend us money for three years, we would have to adapt very fast to this new credit situation, and these tools could be useful". So a first perspective could be to explore more scenarios with local stakeholders to support them in this task. The RPG would be important to ensure that the functioning of the model and its limits are known by local stakeholders, so that the results of the simulations are not misunderstood. Whereas, the MAS model should not be seen as a tool to select a technical and quantitative decision but as a mean to facilitate the exploration of different options beforehand.

A second possible perspective was suggested by the officers of the Department of Public Welfare who would be interested to launch a collective learning process on how villagers could organize themselves within a cooperative to process and sell their agricultural products. The aim is to limit the negative effects of important price fluctuations on the market for their horticultural products and the topic corresponds to a project launched by the development agency with the villagers. This proposition illustrates the fact that the process could move in another very different direction, with a new ComMod cycle based on a new RPG and associated model.

A third possible evolution was suggested by participants who were asked what other stakeholders should be invited to a future gaming session. They answered that the TAO (sub-district administration) officers should be invited to play their own role into the game, "so that they know what is happening in the village". Except the local officers of the Department of Public Welfare, official representatives of administrations at a higher level were neither integrated into the model nor invited to the participatory workshops so far because we thought that their presence could have intimidated villagers and brought the collective discussions to a standstill. The villagers' suggestion to invite TAO officers means that they feel now rather confident in using the proposed tools. As discussed in the final part of this article, this underlines the need (in the eyes of participants) to reinforce institutional linkages to increase the impact of the ComMod process.

Evaluation of the process and lessons learnt

In the following sections, we first analyze the collective learning process that was stimulated by the use of gaming and simulation tools in this Commod process. Second we identify the methodological aspects that contributed to the successes of this process, in particular the flexibility of the gaming and simulation tools. Third we underline its current limits and some perspectives of improvements.

Evaluation of the collective learning process

How to evaluate a learning process? With which criteria? According to Van der Veen (2000), such an evaluation depends on the type of learning. This author distinguishes three types of learning : reproductive learning (linear transmission of knowledge), communicative learning (constructing with others an inter-subjective understanding of the subject), and transformative learning (changes in perspectives leading to more inclusive views of the subject). In our case study, we aimed at facilitating a combination of communicative and transformative learning. In the case of reproductive learning, you can evaluate and measure how much new knowledge participants can demonstrate, if they use it in practice and whether this influence their results. If this method still seems to apply in certain situations of communicative learning, Van der Veen states that it is clearly more tricky for transformative learning. In this case the only option is to adopt a rather qualitative self-assessment by participants, i.e. to ask them whether participation led to a perspective transformation, what kind of transformation it was, and how it changed their behaviour and results. This is what we did in the interviews the day after the game, and again three weeks later.

To begin with, we propose to answer the question: what did people learn and how? In particular, what type of learning occurred, and how was it stimulated by the association of the simulation and gaming tools? We distinguish between the researchers' and the local stakeholders' learning processes.

What did the researcher learn and how? In this process, researchers learnt in three different ways. First, the ComMod process triggered an interactive exchange of perspectives on the system under study with the local stakeholders. The first game was a first

representation of the situation by the researchers focusing on agro-ecological aspects of soil erosion. The game allowed the players to understand this representation and to react on it. They found this representation realistic (this is a form of validation), but they requested some changes to better fit to their representation of the problem of soil erosion and to their preferred way to alleviate it, i.e. to introduce socio-economic dimensions related to the adoption of perennial crops. In the second ComMod cycle, the adapted representation of the situation triggered more discussions among stakeholders themselves. According to Duke (1974), this is the main validation of a game.

Second, researchers could improve their understanding of the situation thanks to the observation of players' behaviours. They elucidated tacit knowledge about the local credit system, and in particular the distribution of power amongst villagers in the decision making process regarding the allocation of formal credit. Such tacit knowledge explains the difference between the way people say they behave (this corresponds to the limited knowledge acquired from previous interviews), and their actual behaviour (whose several aspects were revealed in the game because of the spontaneity it triggers).

Third, the simulations run with the improved model (integrating the knowledge acquired during the game) allowed the research team to better understand the functioning of the complex system under study.

What did local stakeholders learn and how? The first ComMod cycle triggered exchanges mainly between researchers and participants, whereas in the second one, the participants emphasized in the interviews that the experiment allowed them to better understand each other's situations and points of views, by providing a kind of "democratic" (in the words of one of them) platform for communication that does not exist in their current social and institutional situation. They could in particular better understand the kind of difficulties faced by others and could exchange their different views regarding the credit issue. A community leader declared that "in every day life, everyone has his own problems; there is no place where we can think all together like in the game". The game triggered an initial phase of communicative learning among participants that was facilitated by the fact that they share a common "language or jargon derived from the game event" (Duke 1974, p 64). This phase triggered the collective definition of a desired situation.

Second, local stakeholders could improve their understanding of the functioning of the complex system by exploring "what if" questions. In the learning process, this corresponds to a phase during which they wonder how they could reach the identified desired situation. This was triggered by the exploration of scenarios with the game and with the MAS model (learning process based on discovering and experimentation). As the community leader mentioned: "The players can try by themselves (how to plan to invest in plantations). It is more efficient than speaking." According to another participant, the game was said to "help to think in advance" as during a session, players could observe 6 cropping seasons and assess the effects of their choices. "In every day life we do not have the opportunity to think in advance. We can only think to grow maize each year to buy and eat rice".

Argyris and Schön (1996) distinguish between single and double loop collective learning. Single loop learning occur when people change their existing practices without changing their beliefs, norms or values. In double loop learning, changes take place also in their underlying insights and principles. This corresponds to transformative learning. In our case study, participants mentioned several times that this ComMod experiment allowed them to

think differently than in "every day life". "Without the game, we would go on in our every day life", said a participant. This is an evidence of transformative learning.

Factors contributing to the success of this collective learning process

Increased participation of local stakeholders. At least two observations denote an increased participation of local stakeholders in the ComMod process. First, whereas following the RPG 1 sessions, dialogue between researchers and the local stakeholders dominated, the RPG 2 stimulated more dialogue among local stakeholders themselves.

Second, whereas in the 1st cycle the participants mainly suggested changes in the model to better fit to their representation of the reality, in the 2nd cycle, their suggestions were more oriented towards exploration of "what if" questions (scenarios of new credit rules). This evolution can be seen as an expression of a phenomenon described by Duke (1974) as "initial inertia", i.e. "the initial difficulty of getting players involved into a game" (p.205). The first cycle allowed stakeholders to overcome this "initial inertia" and to become familiar with its language and representations. Once they got a global picture of the complex system represented in the game, they were more at ease and could suggest changes. Then, in the second ComMod cycle, they had entered a stage where their skills in the game allowed them to explore new options.

This increased participation of local stakeholders is a positive evaluation of the process as its overall objective is to enable them to participate genuinely in decision making processes in complex NRM situations. Beside the phenomenon of initial inertia, two factors seem to contribute to this positive evolution. First, the research team considers participation as a goal, and not as a mean, and therefore paid attention to the evaluation of the process by the participants themselves. The research team adjusted its tools according to their requests, so that they focused on questions that local stakeholders themselves had raised. Second, the flexibility of the tools was important to achieve this, as discussed in the following section.

Highly flexible tools needed to support evolving learning process. Duke wrote in 1974: "Future's languages are a dynamic communication form; they must respond during use to changing perceptions of the problem." (p. 51). This experiment illustrates how the simulation and gaming tools were flexibly adjusted to the changing local context and stakeholders' preoccupations to support the collective learning process.

The first models and game focusing on erosion were the researchers' initial interpretation of the situation and problem. Then changes were introduced to match the representation and aspirations of the local stakeholders. We added new socioeconomic dynamics interacting with the existing dynamics such as decision making processes regarding investment in perennial crops or off-farm activities, and deleted some other ones. We introduced new stakeholders such as loan sharks or government fund committees and added new characteristics to the existing stakeholders. We created new socio-economic indicators and representations and left aside some other ones. The flexibility of the modelling tool is partly due to the fact that MAS is an object-oriented modelling approach that offers the possibility to add or delete agents or to modify the model features and object behaviour without having to change the whole model. Moreover, the CORMAS platform, tailored to facilitate the modelling process thanks to a certain number of predefined algorithm, is a particularly "open" framework that does not constrain the modeller too much. The RPG tailored

specifically for the experiment also presented the advantage to be completely adaptable. During the workshop, local stakeholders saw their critical remarks and propositions for the future included in the model and the role playing game.

Another interesting point of this experiment is the fact the initial model was simplified to facilitate the comprehension, ease-of-use and better focus on the issue at stake of the local stakeholders. When dealing with complex agro-ecosystems, researchers can be tempted to build more and more complex models. The transition from the initial very sophisticated GIS-based model (MAE SALAEP 1) to the much more simple MAE SALAEP 2.1 illustrates that the evolution does not necessary lead to an increased sophistication of the tools. The most useful models for local stakeholders are not necessary the most exhaustive ones. Each model is a subjective extraction of the key relevant dynamics of the system at a particular moment of the collective learning process among particular stakeholders. The generated family of models is a trace of this collective learning process amongst all stakeholders (including researchers).

The need for a stronger institutional linkage

Dialogue of higher institutional levels. Although the process led to changes in people's perceptions, it did not lead to concrete impacts for the community, mainly because of a lack of institutional support so far. This is quite evident for the suggestion to change the grace period of the government fund as it is decided at the government level. But beyond this simple explanation, this raises an important question. A member of the government fund committee played the game, but he did not participate very much in the debates because as he said, "to change the rules, all the committee members must agree on them" and he knew that "some of them would not agree". Whether or not it is in the interest of the local institutions to participate to a collective negotiation process with the villagers is a crucial question. The need to establish dialogue with higher institutional levels is the reason why among the three identified paths toward a 3rd ComMod cycle, we will opt for the 3rd one, i.e. the integration of the TAO (sub-district administration) officers in the game and model. As villagers themselves requested their presence, we have a good opportunity to test the efficiency of the ComMod process to facilitate such a dialogue.

Involvement of a local facilitator. The way the member of the government fund committee expresses his reluctance to changes also illustrates the fact that rules and institutions are deeply rooted and cannot be changed within a few weeks. This underlines the need for more continuity in the process, what could be achieved by the greater involvement of people from local institutions as facilitators. We initially envisaged an eventual involvement of the two officers of the local governmental agency (Department of Public Welfare) that facilitated our research activities. The main one in charge of Mae Salaep village has a classic view of rural development in which the effective participation of local stakeholders is limited. However, his attitude changed between the RPG 1 and RPG 2 sessions from a very interventionist to a more listening one. The question remains whether or not he (and his agency) will involve further in the ComMod process in the future. If he does, another question will be raised that is related to his non-neutrality position in the debates.

Conclusion

The combination of simulation and role playing games explored in this study flexible accompanied a collective learning processes on complex Natural Resources Management (NRM) issues within a community. It stimulated exchange of view points and dialogue between researchers and stakeholders, and more importantly, among stakeholders themselves. But what to do to ensure that this kind of experiment does not remain only a dialogue among a few villagers that is admittedly very interesting for the researchers but that has no other repercussion for the villagers themselves? How to strengthen and extent the effects of ComMod experiments?

When thinking about an extension of ComMod approaches in northern Thailand, a first limit that comes to mind is the fact that it is reasonably not possible to invest as much time as we did in this experiment in many villages across the region. This region is characterized by a important heterogeneity in space. The three main mountainous chains dividing this region have supported the implantation of various isolated minority communities that have all develop their own local agrarian history. Despite their heterogeneity, many communities are confronted by the same kind of NRM problems. The tools designed to support dialogue to solve conflicts over land, water or forest resources in one community could be useful to other communities. The flexibility of the tools would be once more a very valuable characteristic.
A first way to up-scale the ComMod approach is the training of a network of practitioners interested by this approach and the multiplication of local ComMod experiments. A complementary way to strengthen and extend the approach would be the dialogue with organizations at higher level. If within a community, people want to change things, they need the support of these higher levels of organization. In return, the changes at these levels of organization – and in particular government agencies- can be on benefit of several local communities.

The ideal would be that these organizations themselves adopt such approaches. The effective adoption of participation by government agencies is a challenge in a kingdom like Thailand that has traditionally had a highly centralized form of governance. However the current process of decentralization, and in particular the 1997 Constitution and the establishment of elected *tambon* councils at the sub-district level, constitute important opportunities to remodel the institutional framework in a way favouring dialogue between local communities and the once untouchable bureaucracy. Our future challenge is to test and adapt ComMod approach to facilitate such a dialogue.

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